CLAIMS

1. A heater coil for a gas sensor used in a catalytic combustion gas sensor, comprising:

a bead portion of which an electrical characteristic value is varied by combustion heat generated when a gas is burned; and

lead portions extending from both ends of the bead portion, wherein

the bead portion is constituted of an n-fold coil formed by winding a plain wire into a coil, the plain wire formed with an (n-1)-fold coil that is wound into a coil, where n is an integer equal to or larger than two.

2. The heater coil for a gas sensor according to claim 1, wherein the lead portions are constituted of an (n-1)-fold coil.

3. The heater for a gas sensor according to claim 1 or 2, wherein a wire diameter of a non-coiled raw wire that is a starting material is equal to or larger than 1 μm and equal to or smaller than 100 μm.

4. The heater coil for a gas sensor according to claim 1 or 2, wherein a wire diameter of a non-coiled raw wire that is a starting material is equal to or larger than 10 μm and equal to or smaller than 50 μm.

5. The heater coil for a gas sensor according to claim 1 or 2, wherein a wire diameter of a non-coiled raw wire that is a starting material is equal to or larger than 20 μm and equal to or smaller than 30 μm.

6. The heater coil for a gas sensor according to claim 1 or 2, wherein a winding diameter of an m-fold coil is equal to or larger than 0.5 times and equal to or smaller than 20 times as large as a diameter of a core metal used for winding into a coil when the m-fold coil is manufactured, where m is an integer equal to or larger than one and equal to or smaller than n.

7. The heater coil for a gas sensor according to claim 1 or 2, wherein a winding diameter of an m-fold coil is equal to or larger than 1 time and equal to or smaller than 10 times as large as a diameter of a core metal used for winding into a coil when the m-fold coil is manufactured, where m is an integer equal to or larger than one and equal to or smaller than n.

8. The heater coil for a gas sensor according to claim 1 or 2, wherein number of turns of the n-fold coil is equal to or larger than 1 and equal to or smaller than 30.

9. The heater coil for a gas sensor according to claim 1 or 2, wherein, length of a gap between a wound portion of a k-th turn and a wound portion of a (k+1)-th turn in the n-fold coil is equal to or larger than 0.5 times and equal to or smaller than 10 times as large as a diameter of the plain wire formed by the (n-1)-fold coil, where k is an integer equal to or larger than one.

10. The heater coil for a gas sensor according to claim 1 or 2, wherein the heater coil is constituted of a wire material made of platinum.

11. The heater coil for a gas sensor according to claim 1

or 2, wherein the heater coil is constituted of a wire material made of platinum based alloy.

12. A heater coil for a gas sensor used in a catalytic combustion gas sensor, comprising:

a bead portion of which an electrical characteristic value is varied by combustion heat generated when a gas is burned; and

lead portions extending from both ends of the bead portion, wherein

the lead portions are wound into a coil.

13. A detecting element for a gas sensor used in a catalytic combustion gas sensor, comprising:

a heater coil including

a bead portion of which an electrical characteristic value is varied by combustion heat generated when a gas is burned; and

lead portions extending from both ends of the bead portion;

a heat conductive layer covering the bead portion; and

a catalyst layer adhered on a surface of the heat conductive layer, wherein

the bead portion is constituted of an n-fold coil formed by winding a plain wire into a coil, the plain wire formed with an (n-1)-fold coil that is wound into a coil, where n is an integer equal to or larger than two.

14. The detecting element for a gas sensor according to claim 13, wherein the lead portions of the heater coil is constituted of an (n-1)-fold coil.

15. The detecting element for a gas sensor according to

claim 13 or 14, wherein a wire diameter of a non-coiled raw wire that is a starting material of the heater coil is equal to or larger than 1 μm and equal to or smaller than 100 μm.

16. The detecting element for a gas sensor according to claim 13 or 14, wherein a wire diameter of a non-coiled raw wire that is a starting material of the heater coil is equal to or larger than 10 μm and equal to or smaller than 50 μm.

17. The detecting element for a gas sensor according to claim 13 or 14, wherein a wire diameter of a non-coiled raw wire that is a starting material of the heater coil is equal to or larger than 20 μm and equal to or smaller than 30 μm.

18. The detecting element for a gas sensor according to claim 13 or 14, wherein a winding diameter of an m-fold coil of the heater coil is equal to or larger than 0.5 times and equal to or smaller than 20 times as large as a diameter of a core metal used for winding into a coil when the m-fold coil is manufactured, where m is an integer equal to or larger than one and equal to or smaller than n.

19. The detecting element for a gas sensor according to claim 13 or 14, wherein a winding diameter of an m-fold coil of the heater coil is equal to or larger than 1 times and equal to or smaller than 10 times as large as a diameter of a core metal used for winding into a coil when the m-fold coil is manufactured, where m is an integer equal to or larger than one and equal to or smaller than n.

20. The detecting element for a gas sensor according to claim 13 or 14, wherein number of turns of the n-fold coil of the heater coil is equal to or larger than 1 and equal to or smaller than 30.

21. The detecting element for a gas sensor according to claim 13 or 14, wherein, length of a gap between a wound portion of a k-th turn and a wound portion of a (k+1)-th turn in the n-fold coil is equal to or larger than 0.5 times and equal to or smaller than 10 times as large as a diameter of the plain wire formed by the (n-1)-fold coil, where k is an integer equal to or larger than one.

22. The detecting element for a gas sensor according to claim 13 or 14, wherein the heater coil is constituted of a wire material of platinum.

23. The detecting element for a gas sensor according to claim 13 or 14, wherein the heater coil is constituted of a wire material of platinum based alloy.

24. A detecting element for a gas sensor used in a catalytic combustion gas sensor, comprising:

a heater coil including

a bead portion of which an electrical characteristic value is varied by combustion heat generated when a gas is burned; and

lead portions extending from both ends of the bead portion;

a heat conductive layer covering the bead portion; and

a catalyst layer adhered on a surface of the heat conductive layer, wherein

the lead portions of the heater coil are wound in a coil.

25. A catalytic combustion gas sensor comprising:

a detecting element including

a heater coil including

a bead portion of which an electrical characteristic value is varied by combustion heat generated when a gas is burned; and

lead portions extending from both ends of the bead portion;

a heat conductive layer covering the bead portion; and

a catalyst layer adhered on a surface of the heat conductive layer, wherein

the bead portion is constituted of an n-fold coil formed by winding a plain wire into a coil, the plain wire formed with an (n-1)-fold coil that is wound into a coil, where n is an integer equal to or larger than two;

a compensating element connected in series with the detecting element, and including another heater coil having a same configuration as that of the heater coil;

a first resistive element;

a second resistive element connected in series with the first resistive element; and

a power source that applies a DC voltage respectively across both ends of a series-connected body formed with the detecting element and the compensating element, and a series-connected body formed with the first resistive element and the second resistive element, wherein

the detecting element, the compensating element, the first resistive element, and the second resistive element form a Wheatstone bridge circuit, and

a voltage across, a connecting node between the detecting element and the compensating element, and a connecting node between the first resistive element and the second resistive element is output from the Wheatstone bridge circuit.

26. The catalytic combustion gas sensor according to claim 25, wherein the lead portions of the heater coil is constituted of an (n-1)-fold coil.

27. The catalytic combustion gas sensor according to claim 25 or 26, wherein a wire diameter of a non-coiled raw wire that is a starting material of the heater coil is equal to or larger than 1 μm and equal to or smaller than 100 μm.

28. The catalytic combustion gas sensor according to claim 25 or 26, wherein a wire diameter of a non-coiled raw wire that is a starting material of the heater coil is equal to or larger than 10 μm and equal to or smaller than 50 μm.

29. The catalytic combustion gas sensor according to claim 25 or 26, wherein a wire diameter of a non-coiled raw wire that is a starting material of the heater coil is equal to or larger than 20 μm and equal to or smaller than 30 μm.

30. The catalytic combustion gas sensor according to claim 25 or 26, wherein a winding diameter of an m-fold coil of the heater coil is equal to or larger than 0.5 times and equal to or smaller than 20 times as large as a diameter of a core metal used for winding into a coil when the m-fold coil is manufactured, where m is an integer equal to or larger than one and equal to or smaller than n.

31. The catalytic combustion gas sensor according to claim 25 or 26, wherein a winding diameter of an m-fold coil of the heater coil is equal to or larger than 1 times and equal to or smaller than 10 times as large as a diameter of a core metal used for winding into a coil when the m-fold coil is manufactured, where m is an integer equal to or larger than one and equal to or smaller than n.

32. The catalytic combustion gas sensor according to claim 25 or 26, wherein number of turns of the n-fold coil of the heater coil is equal to or larger than 1 and equal to or smaller than 30.

33. The catalytic combustion gas sensor according to claim 25 or 26, wherein, length of a gap between a wound portion of a k-th turn and a wound portion of a (k+1)-th turn in the n-fold coil is equal to or larger than 0.5 times and equal to or smaller than 10 times as large as a diameter of the plain wire formed by the (n-1)-fold coil, where k is an integer equal to or larger than one.

34. The catalytic combustion gas sensor according to claim 25 or 26, wherein the heater coil is constituted of a wire material of platinum.

35. The catalytic combustion gas sensor according to claim 25 or 26, wherein the heater coil is constituted of a wire material of platinum based alloy.

36. A catalytic combustion gas sensor comprising:
a detecting element including
a heater coil including

a bead portion of which an electrical characteristic value is varied by combustion heat generated when a gas is burned; and

lead portions extending from both ends of the bead portion;

a heat conductive layer covering the bead portion; and

a catalyst layer adhered on a surface of the heat conductive layer, wherein

the lead portions are wound into a coil;

a compensating element connected in series with the detecting element, and including another heater coil having a same configuration as that of the heater coil;

a first resistive element;

a second resistive element connected in series with the first resistive element; and

a power source that applies a DC voltage respectively across both ends of a series-connected body formed with the detecting element and the compensating element, and a series-connected body formed with the first resistive element and the second resistive element, wherein

the detecting element, the compensating element, the first resistive element, and the second resistive element form a Wheatstone bridge circuit, and

a voltage across, a connecting node between the detecting element and the compensating element, and a connecting node between the first resistive element and the second resistive element is output from the Wheatstone bridge circuit.

37. A catalytic combustion gas sensor that detects presence of a combustible gas based on variation of an electrical characteristic value of a heater coil obtained

when the characteristic value is varied by combustion heat generated by burning of a gas that the gas sensor has contacted, the catalytic combustion gas sensor comprising:

a heater coil of which at least both ends are wound into a coil;

electrodes respectively welded to coiled portions on the both sides of the heater coil; and

a sintered body covering a portion of the heater coil, wherein

an alloy layer including at least one metal element constituting the electrodes at a higher percentage than a composing percentage thereof in the electrodes is present in a bonding boundary between the heater coil and the electrodes.

38. A catalytic combustion gas sensor that detects presence of a combustible gas based on variation of an electrical characteristic value of a heater coil obtained when the characteristic value is varied by combustion heat generated by burning of a gas that the gas sensor has contacted, the catalytic combustion gas sensor comprising:

a heater coil of which at least both ends are wound into a coil;

electrodes respectively welded to coiled portions on both sides of the heater coil; and

a sintered body covering a portion of the heater coil, wherein

an alloy layer including at least one metal element constituting the electrodes at a higher percentage than a composing percentage thereof in the electrodes is present in a bonding boundary between the heater coil and the electrodes, and

a core wire made from a metal element included in the

alloy at a higher percentage than that in the electrodes is provided on an inner side of a coiled portion of the heater coil only in a welded portion of the heater coil and the electrodes.

39. The catalytic combustion gas sensor according to claim 37 or 38, wherein the metal element included in the alloy at a higher percentage than that in the electrodes has stronger ionization tendency than the metal constituting the heater coil.

40. The catalytic combustion gas sensor according to claim 37 or 38, wherein

the heater coil is made from any one of platinum and platinum alloy,

the electrodes are made of alloy including nickel, and

the metal element included in the alloy at a higher percentage than that in the electrodes is nickel.

41. The catalytic combustion gas sensor according to claim 37 or 38, wherein at least a part of the portion covered with the sintered body is a coiled coil formed by further winding a coiled wire into a coil, the coiled wire formed by winding a wire material into a coil.

42. A catalytic combustion gas sensor that detects presence of a combustible gas based on variation of an electrical characteristic value of a heater coil obtained when the characteristic value is varied by combustion heat generated by burning of a gas that the gas sensor has contacted, the catalytic combustion gas sensor comprising:

a heater coil of which at least both ends are wound into a coil;

electrodes respectively welded to coiled portions on both sides of the heater coil; and

a sintered body covering a portion of the heater coil, wherein

an alloy layer generated by alloying a metal element not included in any of the heater coil and the electrodes and at least one metal element constituting the electrodes is present in a bonding boundary between the heater coil and the electrodes.

43. A catalytic combustion gas sensor that detects presence of a combustible gas based on variation of an electrical characteristic value of a heater coil obtained when the characteristic value is varied by combustion heat generated by burning of a gas that the gas sensor has contacted, the catalytic combustion gas sensor comprising:

a heater coil of which at least both ends are wound into a coil;

electrodes respectively welded to coiled portions on both sides of the heater coil; and

a sintered body covering a portion of the heater coil, wherein

an alloy layer generated by alloying a metal element not included in any of the heater coil and the electrodes and at least one metal element constituting the electrodes is present in the bonding boundary between the heater coil and the electrodes, and

a core wire made from a metal element included in the alloy layer but not included in any of the heater coil and the electrodes is provided on an inner side of the coiled portion of the heater coil only at a welded portion of the heater coil and the electrodes.

44. The catalytic combustion gas sensor according to claim 42 or 43, wherein the metal element included in the alloy layer but not included in any of the heater coil and the electrodes has stronger ionization tendency than the metal constituting the heater coil.

45. The catalytic combustion gas sensor according to claim 42 or 43, wherein at least a part of the portion covered with the sintered body is a coiled coil formed by further winding a coiled wire into a coil, the coiled wire formed by winding a wire material into a coil.

46. A manufacturing method of a catalytic combustion gas sensor that detects presence of a combustible gas based on variation of an electrical characteristic value of a heater coil obtained when the characteristic value is varied by combustion heat generated by burning of a gas that the gas sensor has contacted, the manufacturing method comprising:

a coil manufacturing step of manufacturing a heater coil of which at least both ends thereof respectively have been formed into a coil by being wound on a core wire;

a welding step of welding coiled portions on both ends of the heater coil respectively to electrode in a state in which the coiled portions are wound on a core wire;

a core wire eliminating step of eliminating the core wire; and

a sintered-body coating step of coating a portion of the heater coil with a sintered body, the portion from which the core wire is eliminated.

47. A manufacturing method of a catalytic combustion gas sensor that detects presence of a combustible gas based on variation of an electrical characteristic value of a heater

coil obtained when the characteristic value is varied by combustion heat generated by burning of a gas that the gas sensor has contacted, the manufacturing method comprising:

a coil manufacturing step of manufacturing a heater coil of which at least both ends thereof respectively have been formed into a coil by being wound on a core wire;

a welding step of welding coiled portions on both ends of the heater coil respectively to electrode in a state in which the coiled portions are wound on a core wire;

a core wire eliminating step of eliminating the core wire except welded portions of the heater coil and the electrodes; and

a sintered-body coating step of coating at least a part of a portion of the heater coil with a sintered body, the portion at which the core wire is not present.

48. The manufacturing method of a catalytic combustion gas sensor according to claim 46 or 47, wherein at the welding step, any one of a resistance welding method, a laser welding method, and a thermo-compression bonding method is performed while the ends wound on the core wire of the heater coil is kept pressed to the electrodes.

49. The manufacturing method of a catalytic combustion gas sensor according to claim 46 or 47, wherein

the core wire is made from a metal material that is more basic meal than the constituting material of the heater coil, and only the core wire is eliminated by etching at the core wire eliminating step.

50. The manufacturing method of a catalytic combustion gas sensor according to claim 46 or 47, wherein

the core wire is made of nickel,

the heater coil is made of platinum or platinum alloy, and

the core wire is eliminated using an etching liquid for nickel at the core wire eliminating step.

51. The catalytic combustion gas sensor according to claim 46 or 47, wherein at the coil manufacturing step, at least a part of the portion of the heater coil covered with the sintered body is formed into a coiled coil that is formed by further winding a coiled wire into a coil, the coiled wire wound on the core wire.

52. The manufacturing method of a catalytic combustion gas sensor according to claim 46 or 47, wherein the core wire also acts as brazing material to bond the heater coil and the electrodes.